ASTRONOMY BEHIND THE HEADLINES
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Episode 7: GAMMA RAY BURSTS
with Dr. Dale Frail, National Radio Astronomy Observatory

Welcome to *Astronomy Behind the Headlines,* a production of the Astronomical Society of the Pacific. In this episode, we're exploring gamma-ray bursts – often called GRBs for short. These are bright flashes of gamma rays from distant regions in the universe. For decades, astronomers have been tracking them, and NASA's *Swift* satellite has detected more than 500 since 2004. However, it's only been relatively recently that astronomers have figured out what some gamma ray bursts are.

We have with us Dr. Dale Frail -- an astronomer at the National Radio Astronomy Observatory's Very Large Array in New Mexico. He's one of the world's experts in high-energy astrophysics, and in particular, works on understanding the "engines" that power gamma ray bursts.

Welcome to the program, Dr. Frail.

DR. FRAIL: *Thanks for asking me, Carolyn.*

HOST: Tell us about gamma-ray bursts – what causes them?

DR. FRAIL: *Well, we basically divide them into two types – and they're divided by their duration.*

So, there's what we call the long-duration gamma-ray burst; they're about ten seconds long in the gamma rays themselves. These, we believe are related to the death of massive stars – so these are stars that are ten to twenty times the mass of our own Sun. And these stars—when they die – when they run out of hydrogen and helium in *their centers, they collapse and create a black hole. The black hole powers the gamma ray burst that we see.*

Then there's the second class, which is the short-duration bursts – they last about a tenth of a second. We think those are related to the gravitational merger of two stars – maybe a white dwarf and a neutron star, or a neutron star and a neutron star. Again, they form a black hole at the formation when they merge. And a briefer flash of gamma rays comes from the short bursts.

And the one commonality between the short bursts and the long bursts is that they're both related to black holes.

HOST: Gamma ray bursts have been described as being some of the most distant events in the universe. What kinds of distances are we talking about?

DR. FRAIL: *These are what we would call cosmological distances, so they are typically at a redshift when the universe was about half of its present age. And we have seen them all the way out to some of the earliest phases of the universe, when the universe was only a few hundred million years old. So, we see them locally, but typically they're at the redshift of 1 or 2, meaning when the universe was about half of its present age. And that's around the time when most of the star formation in the universe was going on, so it's not a coincidence that these events – the death of massive stars – are related to the time when most massive stars were being born.*

HOST: You and your colleagues look at GRBs in radio wavelengths. What do radio signals tell you about these out bursts?

DR. FRAIL: *Well, they tell us a variety of things, but the most important thing for us is they give us a handle on the energy of the central engine. And that's one of the burning questions from the moment when we discovered their afterglows in 1997. We wanted to have a fundamental understanding of how much energy is released by the birth of this black hole.*

HOST: You've referred to these "central engines." What are they?

DR. FRAIL: *We call them central engines because the rotating black hole is what powers the gamma ray burst, and we want to know how much energy has been released. And, the radio emission, by looking at the late-time radio emission, you're able to get a handle on what the true energy release was, and that's allowed us to really pinpoint how much energy that these central engines give rise to, and how that energy is collimated.*

HOST: What you mean by how the energy is collimated?

DR. FRAIL: *The energy that we see, we believe, comes out in a narrow focused beam of light that we call a jet. The energy is probably coming out along the rotation axis of the rotating black hole and expands outward from the collapsing star. And the opening angle of that jet is very narrow – it's probably somewhere typically between 2 degrees to 10 degrees. When you see a gamma ray burst, you're seeing a blast of radiation that's directed towards your line of sight in this very narrow beam.*

Fundamentally, it's got to do with the conservation of angular momentum. When you collapse something, the energy has to go out somewhere, and the energy comes out through the rotation axis of this newly formed black hole.

HOST: Astronomers are saying that studying GRBs gives us a window into the earliest history of the universe. How does that work?

DR. FRAIL: Well*, what's really important about gamma-ray bursts that you have to appreciate right off the bat is that they're bright. And so, astronomers are very interested in the earliest phases of the universe, when the first stars began to turn on, even before the first galaxies were formed. We know that even with our best telescopes today, and the telescopes we have planned, we'll never see those stars directly. But, in a gamma-ray burst, basically over the lifetime of a whole star, a star emits a certain amount of energy. In a gamma-ray burst, it emits all that energy in a very short amount of time – when it does. And so you can see gamma-ray bursts for a long distance and their advantage is that you may not see the birth of the first star, but we will be using these death of these first stars – we can use them to study what the stars looked like before they exploded.*

HOST: What's on the frontier for gamma ray burst research?

DR. FRAIL*: The way I describe the frontier areas in gamma ray bursts are the near, the far, the short, and the hyper. We are very interested in the events that are very far away because they're going to tell us about the birth of those first stars.*

We're interested in events that are very nearby, although they're rare, because there's a smaller volume of the universe around us. The nearby events – meaning in our own local universe, a few hundred megaparsecs. We like those because they're bright – we can study the supernovae that go with them, we can study the jets in great detail. So, the near and the far are great.

The short gamma-ray bursts still remain a mystery to us. We have some ideas that they're related to this coalescence of the white-dwarf-black-hole, white-dwarf-neutron-star, but we haven't got the proof that we need, yet. So, the short is also interesting.

And the hyper – what I mean by that is, we're interested in the energy of the central engine. And so we are going after the hyper-energetic events because those are the ones that have the most difficulty to explain from standard gamma ray burst models.

So, the near, the far, the hyper and the short bursts are sort of what I call the frontier areas. All of them are trying to get at the question of "what is that central engine – what is it about the newly formed black hole that made it special that way?"

HOST: It sounds like a fascinating future for gamma ray burst studies. Thank you for joining us, Dr. Frail.

DR. FRAIL: *thank you, Carolyn*

You can find more information about gamma-ray bursts and current research aimed at understanding them, at the Astronomical Society of the Pacific's Astronomy Behind the Headlines web page at www.astrosociety.org/abh. Thanks for listening!

Special thanks to Dr. Dale Frail